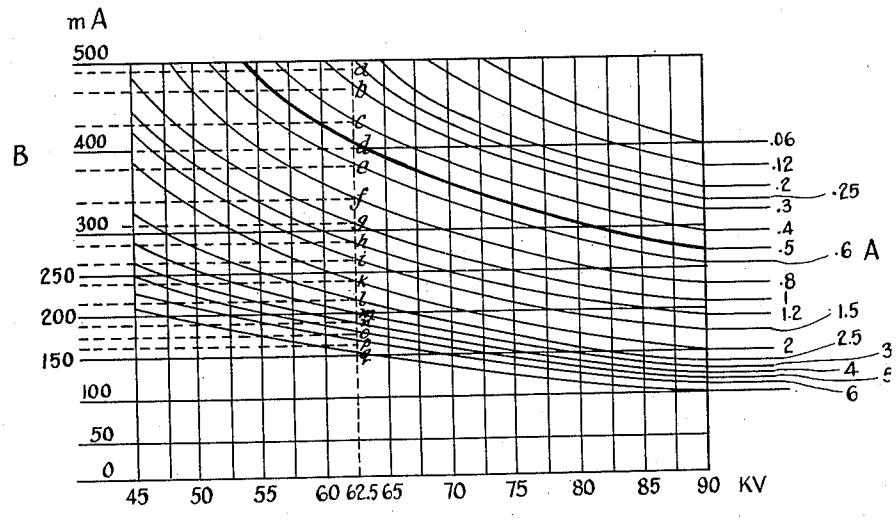
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APPARATUS FOR CONTROLLING THE LOAD ON AN X-RAY TUBE

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Fig. 1.



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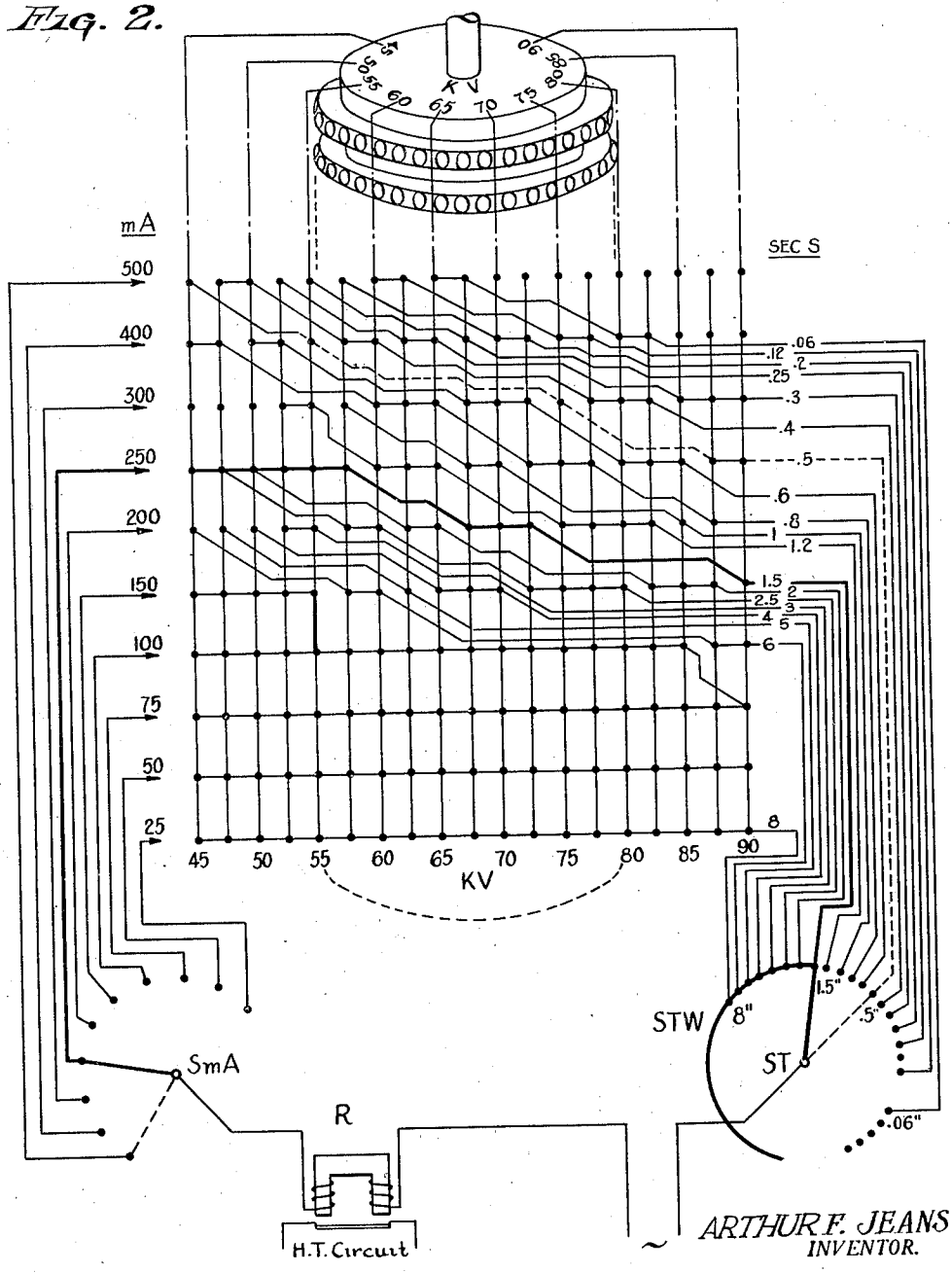
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Fig. 2.



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APPARATUS FOR CONTROLLING THE LOAD ON AN X-RAY TUBE

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4 Claims. (Cl. 250—95)

The load on an X-ray tube is determined by three variables, viz: *k*V, *m*A, and time, and in general diagnostic X-ray apparatus is provided with separate means for controlling the values of each. In order to obtain best radiographic results with a given X-ray tube, it is necessary in many cases to operate the tube at maximum permissible load. If an X-ray tube is to operate at maximum permissible load there must be a definite relationship between the three variables. This relationship can conveniently be represented graphically by a series of characteristic curves plotted with one of the variables as ordinates and another of the variables as abscissae, each curve being for a different value of the third variable. The object of the present invention is to provide for the automatic correlating of the three variables in such a manner as to ensure that overloading can never occur while at the same time enabling close approximation to maximum tolerable load to be achieved. With this object in view, the present invention provides an arrangement for controlling the load on an X-ray tube in which the means for controlling the three variables are separately adjustable but are interlocked in such manner that the tube cannot be operated at settings which would bring about overloading of the tube. The arrangement may be such that all permissible combinations of the three variables, viz: *k*V, *m*A and time, are possible, or it may be such that after free selection of two variables (e. g. *k*V and time) the third variable (*m*A) is automatically selected. In the latter case the load approaches the full permissible load for all combinations of the freely selected variables. According to the present invention, the controls for the three variables are each associated with a device which assumes a position corresponding to the setting of the associated control. Contacts selected by the device associated with one of the controls are connected with contacts selected by the device associated with another of the controls by means of a multi-way connector switch associated with the third control device. The contacts and switch are so related to the tube characteristic as to provide a through connection only when the setting of the three controls is such as to fall within the permissible load. The through connection so provided forms part of a circuit comprising a safety relay controlling the working circuit of the X-ray tube.

In order that the invention may be more readily understood, reference will now be made to the accompanying drawings in which:

Fig. 1 is a graphical representation of typical relationships between the three variables, viz: *m*A, *k*V and time.

Fig. 2 is a diagrammatic representation of a preferred construction for carrying out the present invention.

In Fig. 1, the *m*A values are plotted as ordinates and the *k*V values as abscissae, and separate curves are drawn for a series of different values of the exposure time in seconds. From these curves, it is readily possible to determine the maximum permissible value of any one variable for predetermined values of the other two variables. Thus, for example, the ordinates *a*, *b*, c, etc. represent the maximum permissible *m*A values for a *k*V of 62.5 and an exposure time of 0.25, 0.3, 0.4, etc. second respectively. In practice, the nearest lower available *m*A value to the permissible value has to be chosen.

In the diagrammatic Fig. 2, the switch ST is a multiple-contact switch mechanically coupled to the time switch control in the X-ray apparatus. The switch positions are marked in the drawings with numbers representing the exposure time in seconds as set by the time switch. The central part of Fig. 2, marked *k*V, represents a rotary drum coupled with the *k*V selector switch. The drum itself is indicated in Fig. 2 and is shown fragmentarily in the upper portion of the figure, whereas the central portion is a developed view. On the drum, contact studs are provided which are arranged in rows extending round the periphery of the drum and in rows extending lengthwise of the drum. In the developed view, these contact studs are represented by dots. Each vertical row of dots represents a given *k*V adjustment. On the left hand side of Fig. 2 are shown brushes identified as *m*A 500, 400, 300, etc.: these brushes, which are connected each to one contact of a switch S*m*A, are adapted to cooperate each with one of the horizontal rows of dots (i. e. one of the peripheral rows of contact studs) and to make connection with one contact only in the row in any given setting of the drum. The switch S*m*A is a multiple-contact switch coupled with the *m*A selection switch in the same way as the switch ST is coupled with the time switch. Consequently each horizontal row of dots represents a given *m*A adjustment. Thus the co-ordinates of each dot define given *m*A and *k*V adjustments. The maximum time setting permissible is determined from the characteristic curves of Fig. 1. All the contact studs requiring the same time setting are connected together on the drum, as indicated by the lines which for the greater part extend obliquely upwardly from right to left in Fig. 2. These connecting leads are each connected to a slip ring and the slip rings serve to give a permanent connection between each connecting lead and the corresponding contact on the switch ST.

The switch ST, the drum *k*V, the switch S*m*A and a relay R are connected in series with a source of current. The relay R serves to control the main circuit of the X-ray tube, so that the main circuit is broken if the relay R is not ener-

gized. If desired, the disabling of the main circuit to prevent operation of the X-ray tube may be associated with a visual or other type of signal as is customary.

To enable the operation of the arrangement according to Fig. 2 to be more readily understood certain specific examples will be discussed. Assuming that, as shown, the *k*V drum is so set that the *m*A brushes make contact with the vertical row of contact studs corresponding to 45 *k*V. If then the time control is set for 1.5 seconds, the switch ST takes up the full-line position and the connection through the drum follows the lead shown by a heavy line. This lead extends to the 250 *m*A brush. If, therefore, the switch S*m*A is so set as to be connected with this brush, the circuit of relay R is completed, R is energized and the main circuit is not disabled. Consequently with this admissible setting of the three controls for time, *k*V and *m*A the X-ray tube can be operated. If, however, the *m*A selector were set to a higher value without alteration in the *k*V and time adjustments, e. g., the *m*A selector is set to 500 *m*A, then as shown by the broken-line lead through the *k*V drum, the appropriate setting of the time switch (assuming *k*V to remain at 45) is 0.5 sec.

In addition to the selecting arm, the switch ST preferably carries a wiper arm which moves with the selecting arm and connects in the circuit of the relay R all the timer leads corresponding to time adjustments greater than the selected time. In Fig. 2, this wiper arm is indicated by the arcuate member STW. Owing to the action of the wiper arm the circuit of the relay R is completed at any setting of the *m*A selector not exceeding the permissible maximum current corresponding to the *k*V and time settings. It will be appreciated that the leads through the drum as shown in Fig. 2 are for the case in which the switch ST is equipped with the wiper STW. In the absence of the wiper STW each lead would have to extend round the full working periphery of the drum (as in the case of the 0.8 sec. lead) and not only part of the way (as in the case of the 1.0 sec. lead).

It will be apparent that instead of selecting the *m*A setting by the conventional hand control, the completion of the circuit through the switch ST and one of the leads extending through the drum to one of the brushes *m*A 500 etc., may be made to operate a relay which automatically sets the *m*A selector to the permissible maximum. Alternatively the relay could introduce a mechanical stop into the path of a manually movable *m*A selector handle to prevent movement of the handle into a position beyond the setting corresponding to the permissible maximum loading. Equally the circuit may be used to actuate a visual indicator showing the permissible maximum *m*A value for the previously selected values of *k*V and time.

It will be appreciated that although reference has been made to *k*V control, *m*A control and time control respectively in relation to specific components of the interlocking control arrangement as described above with reference to Fig. 2, any one component could be associated with any desired factor, but the described association is believed to be the most advantageous.

I claim:

1. Apparatus for controlling the main circuit loading potential-, current- and time variables applied to an X-ray tube, comprising means for selecting one of a plurality of predetermined values of one of said variables and comprising a switching member having a plurality of contacts, each contact corresponding to one of said values of said one of said variables, means for selecting one of a plurality of predetermined values of another of said variables and comprising a switching member having a plurality of contacts arranged in a plurality of sets with the corresponding contacts of each set being connected together, the contacts of each set each corresponding to one of said values of the second of said variables and the number of sets of contacts corresponding to the number of values of the first of said variables, means for selecting one of a plurality of predetermined values of the third of said variables and comprising a switching member having a plurality of contacts each corresponding to one of a plurality of values of said third variable and each being connected to a contact of said second switching member at a point at which the product of the three variables represented by the contact of said second switching member is within the maximum permissible loading of the X-ray tube, the three said switching members being connected in series, and means energized through said switches to control the on and off operation of the main circuit of the X-ray tube.

2. Apparatus as claimed in claim 1 in which the contacts of said third switching member are each connected to a contact of said second switching member at a point at which the product of the three variables represented by the contact of said second switching member is substantially equal to maximum permissible loading of the X-ray tube.

3. Apparatus as claimed in claim 1 in which said second switching member is constituted by a rotatable drum and the contacts of the switching member are arranged in rows extending peripherally and longitudinally on the surface of the drum, the number of peripheral rows corresponding to the number of contacts of the first switching member and the number of longitudinal rows corresponding to the number of selectable values of said second variable.

4. Apparatus as claimed in claim 1 in which said second switching member is constituted by a rotatable drum and the contacts of the switching member are arranged in rows extending peripherally and longitudinally on the surface of the drum, the number of peripheral rows corresponding to the number of contacts of the first switching member and the number of longitudinal rows corresponding to the number of selectable values of said second variable, in which a plurality of brush members are individually connected to the contacts of said first switching member and are positioned for selective connection to the contacts of said second switching member, and in which said second switching member comprises a plurality of slip-rings each connected to a contact of said second switching member at a point at which the product of the three variables represented by the said contact is within the maximum permissible loading of the X-ray tube, the said slip-rings corresponding in number to the number of contacts of said third switching member and being connected to the contacts of said third switching member.

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